GEOLOGICAL AND GEOMORPHOLOGICAL STUDIES IN PARTS OF MUNGER DISTRICT, CHHOTANAGPUR PLATEAU, BIHAR, USING REMOTE SENSING TECHNIQUES

DISSERTATION

SUBMITTED IN PARTIAL FULFILMENT
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Master of Philosophy

IN

APPLIED GEOLOGY

By

RAJEEV KUMAR SARASWAT
Reg. No. 200985

Under the Supervision of

Dr. Syed Ahmad Ali
(Reader)

DEPARTMENT OF GEOLOGY
ALIGARH MUSLIM UNIVERSITY
ALIGARH (INDIA)

2005

DEPARTMENT OF GEOLOGY
ALIGARH MUSLIM UNIVERSITY
ALIGARH-202002

Telefax : (0571) 2700615
Internal : 3400
Fax AMU : +91-571-2700528

Ref. No. ....

Dated ....

This is to certify that **Mr. Rajeev Kumar Saraswat** has completed his research work under my supervision for the degree of **Master of Philosophy** of the Aligarh Muslim University Aligarh. This work is an original contribution to my knowledge of the Geological & Geomorphological studies, using Remote Sensing Techniques in parts of Munger District, Bihar and has not been published any where.

He is allowed to summit the work for the M.Phil degree in Applied Geology of the Aligarh Muslim University, Aligarh.

SUPERVISOR

Dr. Syed Ahmad Ali
Reader

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(Rajeev K. Saraswat)

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CHAPTER 1

INTRODUCTION

"Nature to be commanded must be obeyed". The dissertation presents the geology and geomorphology of Munger District, Bihar.

In order to develop the theme data in respect of Geology, Hydrology was collected. The Geomorphologic studies were carried out through visual and some how through Stereo-model interpretation with the use of IRS imagery and aerial photograph of the area/district. The tonal, textural, geotechnical and relief signature of the area were synthesized in terms of geomorphic elements and surfaces the study was supported by ground truth collection in respect of litho types, hydrological setting, ground water frontential of different geomorphic units and their pedological characters.

Area and location: - Munger district, located in the south central part of Bihar between the latitudes 23°22'N & 24°49' N and longitudes 85°36E & 86°31'E.The area forms the part of Chhotanagpur plateau.

Previous work: - Quaternary geological and geomorphological studies and the geoscientific appraisal of the terrain its natural environment and resources have been attended the first time under the "Project Munger".

However considerable work has been done on the geology and Mineral resources peninsular shield area i.e. the southern part of the district since 1874.

The Chhotanagpur gneissic terrain and the associated Bihar Mica Belt area of Munger district is a geologically well-explored area compared to the Kharagpur hill tract.

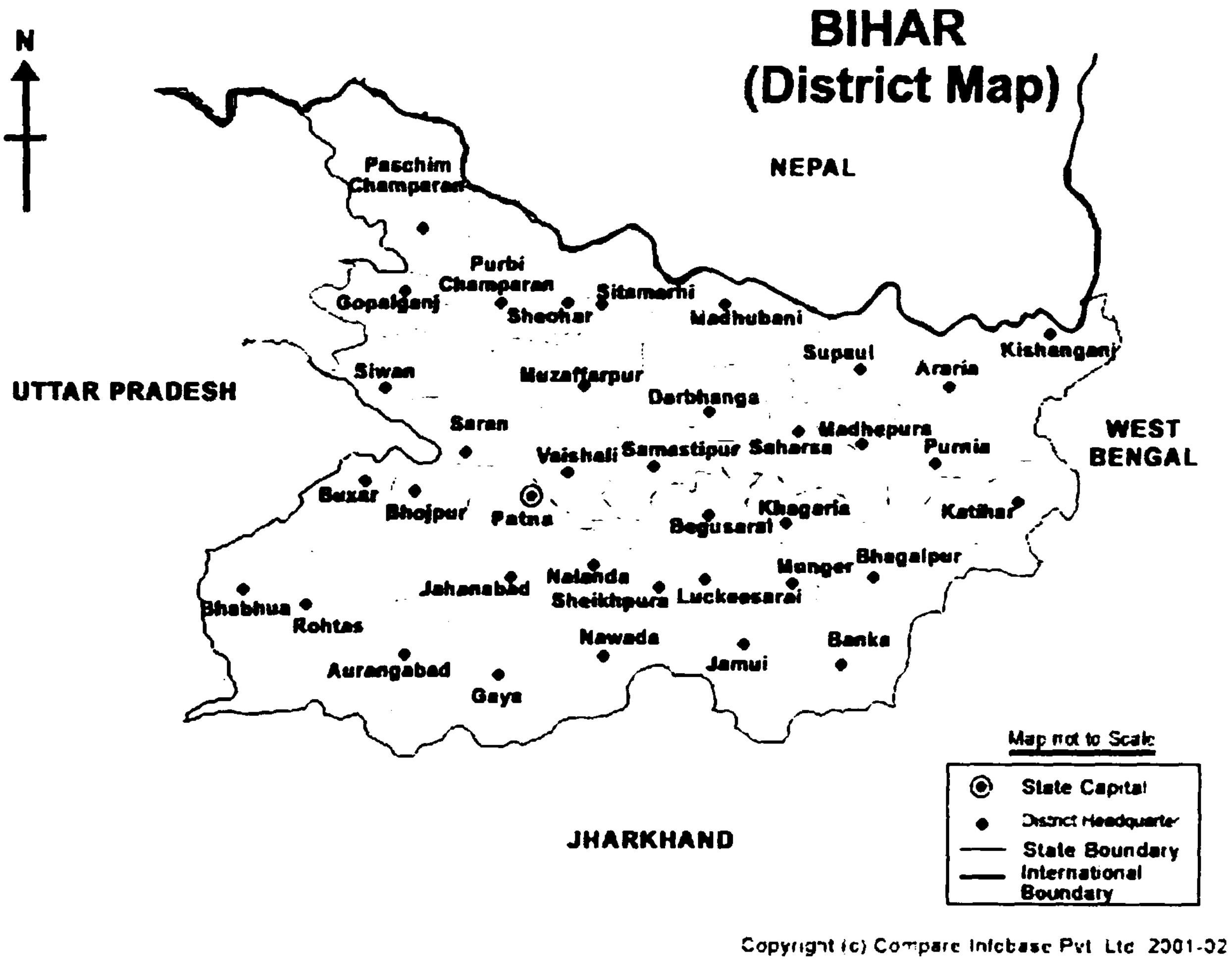
The earliest contribution was Mallet (1904), Dunn (1929, 42), Biswas (1929), Roy et.al (1939), Iyer (1941), Anandakwar (1958), Shastry (1959) Sarkar (1964, 68), Mahadevan & Maithani (1967), Bhatacharya (1974-76).

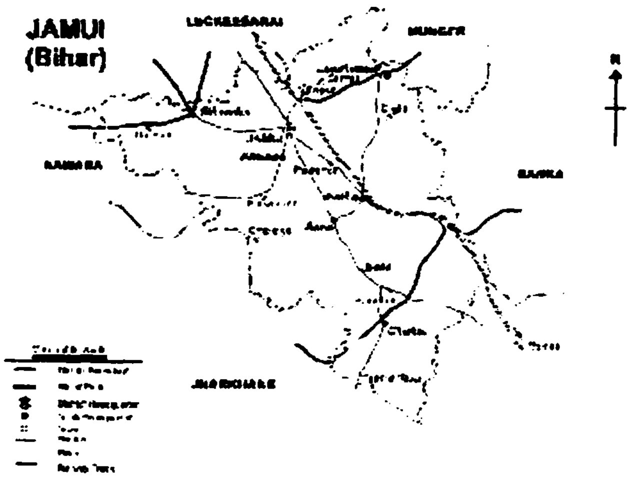
They have studied the various aspects of the Chhotanagpur Gneissic Complex and Belt including Mica Pegmatite.

Climate: - The climate of Munger can be described as a transition between the dry & moderately extreme climate of Northern India & The warm humid climate of Bengal basin. Like the rest Bihar the climatic year of Munger can be divided into four principal seasons viz.

1-Winter- December to February- (Maximum temperature 26.°C and Minimum temperature 3.2°C.)

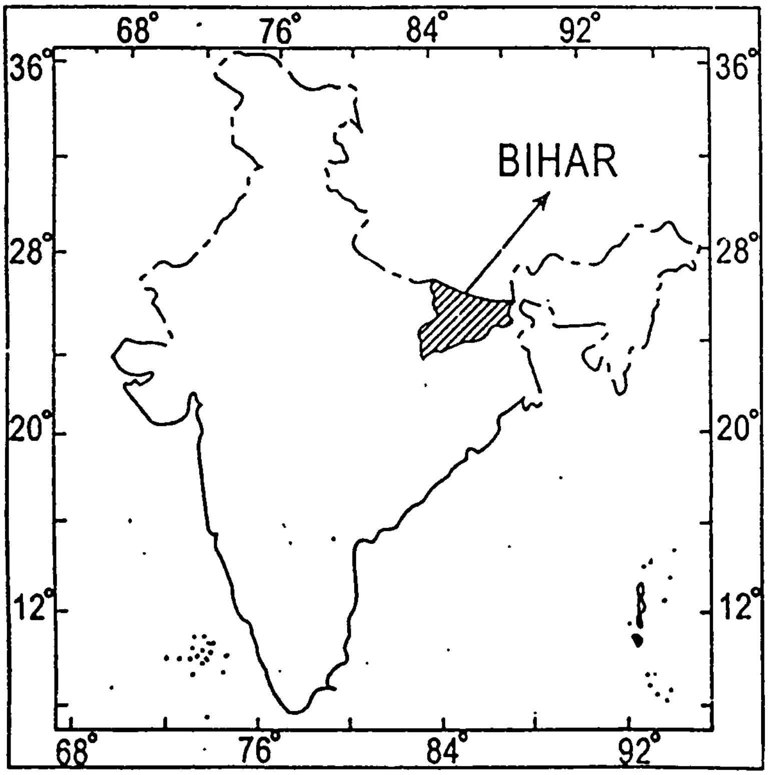
Bihar District Map



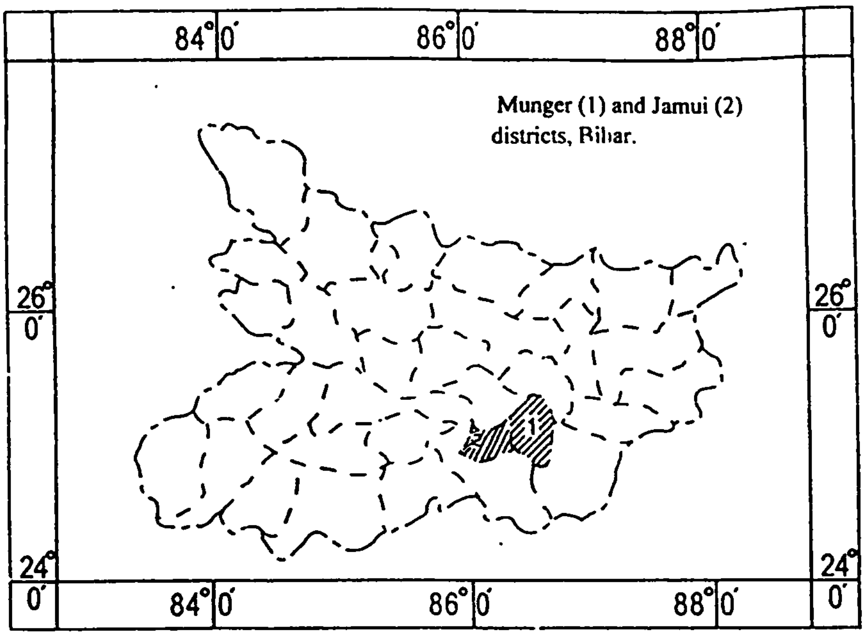


Study Area

KEY MAP



KEY MAP



2-Summer- March to May - Minimum temperature 38 - 42°C & Minimum temperature 8.2 - 19.0°C.

3-Monsoon- June to September.

4-Autumn- October to November.

Scope of the present work- The investigation was primarily directed to evolve parameters for targeting through technology development for the time effective & cost effective methodology.

Remote sensing techniques for establishing relationships between ground water localization & geomorphology were attempted with a view to evolve photo-signature of groundwater zones in different geomorphic Units. In pursuance of above objectives the scope study was enlarged beyond the realm of geomorphology & hydro-geomorphology to geology & pedology. The basic data in respect to hard rock geology & Quaternary litho-stratigraphy of the area were collected through normal survey techniques. This study was necessitated by the fact that the Pedological signature and their responses to the visible part of electromagnetic spectrum collect surgical expression of photo-recognition element of the different geomorphic surfaces & Landform.

CHAPTER-2

METHODOLOGY

During the course of study the following investigation were carried out: -

Survey of India toposheet No. **72-L/1, 72H/13** were procured and a lease map was prepared using the toposheet which helped in planning of transverses in order to collect the ground truth data. Aerial photographs (Photos. – Task no. 518A/170 and Photo No.- 1,2,3,4,5,6) were interpreted & drainage lives were mapped on about 1:63000 scale using mirror & Pocket stereoscope.

Drainage morphometry was carried out through synthesis and quantitative analysis of the drainage map.

Visual Interpretation of following IRS Imagery was carried out using hand lens Light-Table & Dyna-scan Instrument.

1- False colour composite of **IRS-1B** Band **2, 3, 4** on 1:50,000 scales.

Geological, Geomorphological & Structural details were identified, interpreted & delineated using standard interpretation Techniques.

Preliminary geological & geomorphological maps were prepared on 1:50,000 scales toposheets and 1:63000 scale aerial photographs.

Inventory and collection of available toposheets Air-photos and Satellite Images pertaining to the area of investigation.

Preparation of Photo-mosaic of the area in segments, selection of key photographs their annotation with the help of toposheets and selective reconnoiter field transverse.

A broad classification of the terrain into major geomorphic units on the of air-photo interpretation in the laboratory & reconnoitery field transverse.

Pre-field interpretation of the drainage pattern landform assemblage of the broad units identified from the photo-mosaics including a broad appraisal of geology geomorphology.

1- Preparation of base map from 1:50,000 scale survey of India topographical maps or degree sheets of the Munger district.

2- Collection & study of collection data.

3- Pre-liminary scanning of IRS data and preparation of Interpretation key.

4- Visual interpretation of data using light faste images No. Path- Gx 0012 and row 4128.

5- Final cartographic preparation of hydro-geomorphological maps along with legend.

6- Geomorphic features & associated with landforms having ground water potentiality can be recognized on the basis of their spectral features present in the satellite-Image.

CHAPTER-3

REMOTE SENSING & ITS TECHNIQUES IN GEOLOGICAL APPLICATIONS

Remote sensing is broadly defined as collecting and interpreting information about a target without being in physical contact with the object.

Aircraft & Satellite are the common platforms for remote sensing data collection.

Image Interpretation is the act of examining images/ Photographs for the purpose of identifying objects and judging their significance. The interpretation is not restricted to identifying objects on the image.

Visual interpretation of satellite images is being applied successfully in many fields, including Geology, Geography, Agriculture, Water resources, Forestry, etc

.

A systematic study of satellite images usually involves a consideration of two basic visuals.

1- Image Element

2- Terrain Element

Following are the eight characteristic image elements that aid image interpretation:

1-Tone/Colour

2-Texture

3-Pattern

4-Shape

5-Shadows

6-Site

7- Association interpretation elements.

1- Image Elements

1- **Tone/Colour: -** Refers to relative shapes of grey on B/W images or colours on FCC (False Colour Composite) images.

Tone is directly related to reflect to reflectance of light from terrain features. For example- water, which absorbs nearly all incident of light, produces black tone whereas a dry sand reflects a high percentage of light consequently produces very light tone on the image.

2- **Texture-** Refers to the frequency of tonal changes in an image. Texture is produced by an aggregate of unit features, which may be clearly discerned individually on the image. It is a product of their individual shape, size, Pattern, shadow and tone. By definition texture is dependent on the scale. As the scale of the Photographs is reduced the textures of a given object becomes progressively finder & eventually disappears.

Relates to the spatial arrangement of the objects. The repetition of certain general forms or relationships is characteristic of many both natural and man made, and gives objects a pattern, which aids the image interpreter in recognizing them. For example interbedded sedimentary rocks typically give an alternating tonal pattern, which aids in its identification.

3- **Shape: -** Relates to the general form, configuration shape is one of the most important single factors for recognizing objects from images.
e.g. - a railway line is usually readily distinguished from a highway on a dirt road because its shape consists of long straight tangents & gentle curves as opposed to the shape of a highway.

4- **Size: -** The size of an object can be important tool for identification. Objects can be misinterpreted if their sizes are not evaluated properly. Although the third dimension i.e. height of the object is not readily measurable on satellite images but valuable information can be derived from the shadow of the objects.

5- **Shadows: -** are of importance to photo-interpreter in two opposing respects:

(a)- The outline or shape of a shadow affords a profile view of objects, which aids interpretation.
(b)- Objects within shadow reflect little light & are difficult to discern on photographs, which hinders interpretation.

6- **Site: -** Location of objects in relation to other features may be very helpful in identification. Aspect topography geology, soils, vegetation etc. are distinctive factors that the interpreter should use when examining site.

7- **Association:** - For example a flood plain is associated with several fluvial features such as terraces, Meanders, Ox-bow lakes, abandoned channel etc. Similarly sandy plain in a desert is associated with various types of sand dunes.

2-Terrain Elements

In addition to the image elements listed below are also highly useful for image interpretation. They are:

1- Drainage patterns **2- Drainage Density**
3- Topography/Landform **4- Erosion status**

1- **Drainage patterns-** The drainage patterns & is good indictors of landform & bedrock type and also suggests soil characteristics & site drainage conditions. For example dendratic drainage pattern is the most common drainage pattern found in nature. It develops under many terrain conditions including homogeneous unconsolidation materials rock, which confirm resistance to erosion such as horizontally bedded sedimentary rocks & granites terrains.

2- **Drainage Density:** -Drainage density or texture refers to the drainage lines within a given unit area. In given climatic area coarse textured pattern would tend to develop where the soils & rocks have good internal drainage with little surface runoff whereas fine textured pattern would tend to develop where the soils & rocks have poor internal drainage & high surface runoff. Soft easily eroded rocks such as shale would tend to develop fine textured drainage patterns whereas sandstone develops coarse textured drainage patterns.

3- **Topography/Landforms**: - The size & shape of a landform are probably its most important identifying characteristics. There is often a distinct topographic change at the boundary between two landforms as can be seen in several images. Identification of landforms can help to decipher the underlying geology. Often many of the rock types have distinct topographic expression for example, interbedded sedimentary rocks typically expose in the form of alternating ridge & valley topography. Similarly basaltic flows occurs in the form of mesa, hills, Granitic bodies typically form hummocky, Topography, etc.

4- **Erosion:** - In general the deformation status & overall erosion within a given area can be assessed from the image, which aids interpretation particularly, geological mapping purposes. For example a highly deformed & eroded rock unit can be considered older than the surrounding natured characteristic of underlying materials.

CHAPTER-4

GEOLOGY OF THE AREA

Geologically, Munger district can be divided into two domains, viz. 1- the domain of the Quaternary hard rocks restricted to the south of Ganga river and 2- the Domain of Quaternary sediment constituting the valley areas to the north & south Ganga.

1-Pre-Quaternary Rocks: -

Pre-Quaternary rocks of Munger can be divided into two domains viz.

(a) - The domain of the oldest Meta sediments gneisses and southern most part of the district. Fringed towards north by the folded hill ridges of older Meta sedimentary with the intrusive granites followed further northward by the vast Pedi plain of chhotanagpur gneiss complex with occasional low Tors domes. This is followed to the north by

(b)-the domain of low-grade metasedimentaries constitutes small inliers at Sultanganj, Dholpahri, Khajurdih, and Bindravan & Murdi in Belharna-Badua valley at Kastkarni ghat in Munger town and at Silwe & Nabinagar in the Kiul valley.

STRATIGRAPHY

Quaternary sediments

Laterite Unconformity

Intrusive Granite (Kharagpur group)

Alternation of Quaterzite

Phyllite & Slate

Basal conglomerate

Dolerite

Pegmatite & Quartz Veins (Satpura Orogeny)

Foliated granite (Non-prophyritic)
Augun Gneiss

Mica- schist, Quartzite (metamorphites of the Quartz-schist,

Hornblende (Bihar Mica Belt)

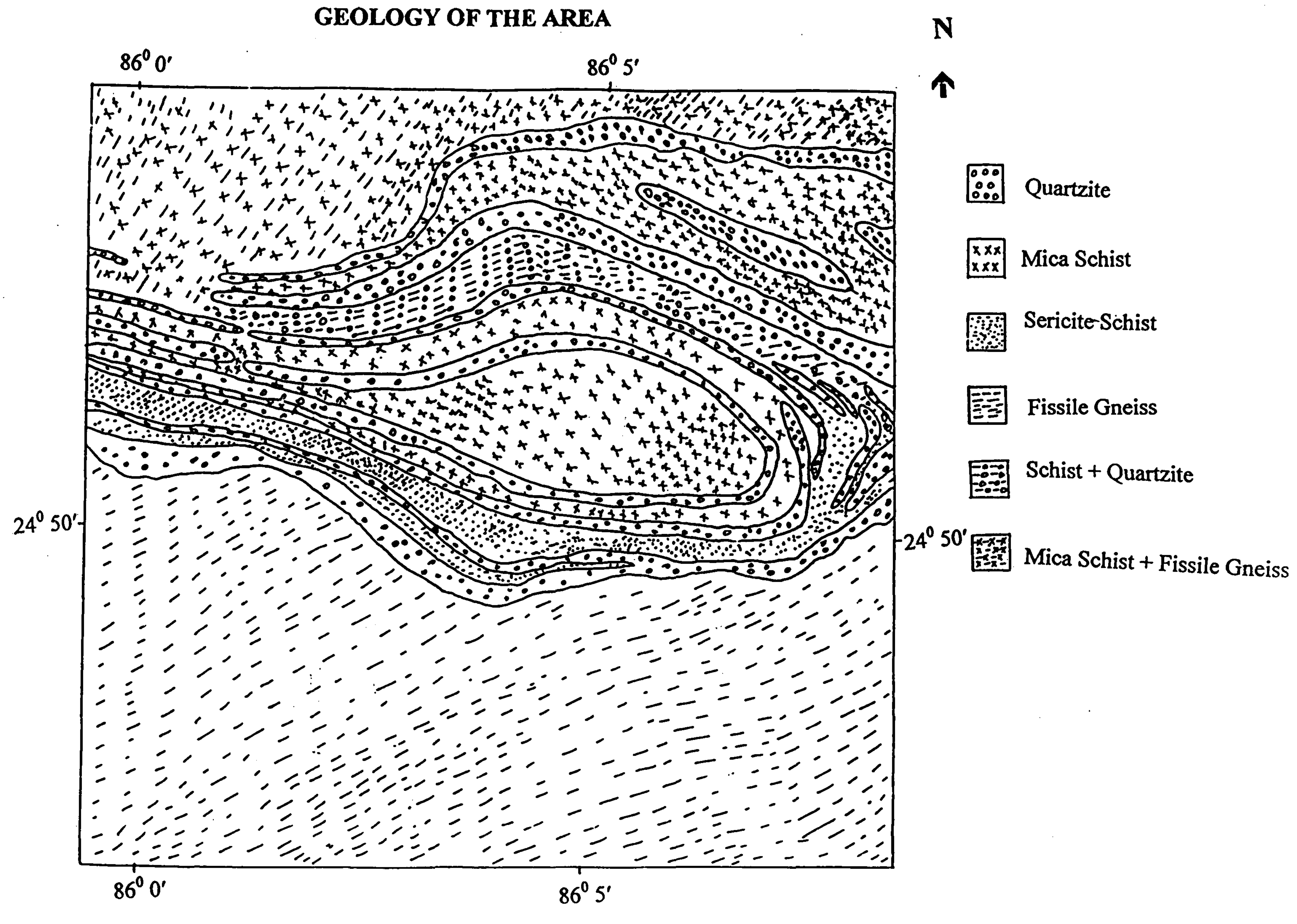
Schist & Gneiss (Chaibasa Group)

Chhotanagpur gneiss Singbhum granite gneiss

Granulite and Amphibolites.

(Older Basement not exposed)

GEOLOGY OF THE AREA



LITHOLOGY

A. Chhotanagpur Group: -

1-Chhotanagpur gneiss: - covering more surface area than other group of rocks is a highly complex rock mass & fairly weathered. It has a subdued topography in strong contrast to the positive topography of the intrusive granites within the mica belt (Gaha et. Al.1977-81) its petrography variant are biotitic gneiss hornblende gneiss, Augen gneiss and Migmatite the granite variety is generally Porphyritic with well-developed phenocrysts of microcline.

In Chhotanagpur gneissic terrain the grade of metamorphism of country rock is within the amphilite facies except for sporadic granulite facies a peak, many of which possibly remain to be demarcated.

2- **Metamorphites of mica belt:** - These rocks have been differented into two sub-groups on the basis of air-photo interpretation followed be field checks (Gaha et. al. 1980)

3- Mica schist & Quartz-mica schist: -The outcrop areas of this type have a gentle rolling topography. The main lithological variants are garnetiferous mica schist biotite, Muscovite schist, Hornblende schist & garnet-mica schist.

4- Quartzites & Quartz schists: - They occur as bonds of variable thickness in association with the former group of rocks and constitute strike ridges of moderate relief.
Intrusive granitic rocks: - There are a few well-defined intrusive granite bodies within the mica belt. They constitute elongated ridges.

5- Augen gneiss: - The rock consists of porphyroblasts of k-feldspar embedded in a fine-grained groundmass of quarts, plagioclase, and biotite together.
Foliated Granite: - The major constituents of these rocks are k-feldspar, Quarts, Plagioclase & Biotite. Garnet, Appatite, Epidote & zircon occur as accessories.

6- Pegmatites: - The Pegmatite is mainly of two types viz.-
Mica-pegmatite containing commercial Muscovites and characterized by dominance of oligoclase & occur in meta-sedimentary rocks.
Mica-poor or mica free type characterized by the dominance of microcline & Quartz occur in the meta-sedimentary rocks as well as with in the granite gneiss.

B. KHARAGPUR GROUP

The main rock type includes several variants of quartzite, Phyllite, Slate, Slate, Sericite schist, Intrusive granite, Quartz vein & Laterite.

A brief description of each of the litho-units is per suited below: -

1- Quartzite: - There are four variants of quartzite in the area viz.
Massive Quartzite Ferruginous massive quartzite.
Feldspathic quartzite constitutes three major and several minor strike ridges.

Trending NNE-SSW in eastern part in consonance with the style of folding similar trend has also been observed in all the inliers of these rocks in alluvial valley.

2- Phyllites: - Phyllite occurs as thick beds alternating with quartzite bands and its trends are in conformity with the quartzite.
They are grayish black grayish white in colour & mainly composed of Illite & quartz.

Slate: - Slate occurs as conformable lenticular bounds of varying dimension within Phyllites & Sericite schists. It is reasonably and other construction and education purposes.

3- QUATERNARY SEDIMENTS

The Quaternary sediments covering the valley to the south & north of the Ganga can be divided into four distinct morphostratigraphic units, which in the order of diminishing antiquity are:

1- Jamui Formation

2- Khagaria Formation

3- Kosi-Ganga Formation

4- Diara Formation

Of these, the Jamui formation has developed only to the south of Ganga and the khagaria fonnation only to the north of the Ganga.

The Ganga-Kosi and Diara formation occur of either side of the Ganga River.

The quaternary sediments of the area, deposited under fluvial environment can be divided in two domains from the nature of the sediments and their provenance. They are:

1- Domain of the sediments derived three-tier terraced landscape in the valley area to the south of the Ganga.

2- Domain of the sediments derived from subdued three tier terraced landscape in the valley are to north of the Ganga.

The sediments of the Ganga constitute the link between the two domains.

1- JAMUI FORMATION

The multiple alluvial fill of Jamui terrace, which is described as the "Jamui formation", constitutes the oldest continental Quaternary deposits in the area & is commonly known as "Older Alluvium" in the Indian Geology.

The alluvium fill of Jamui terrace overlaps and inter fingers with the colluvial & residual surficial cover material on the pediplain in resulting in a transitional contact between the two-morphostratigraphic units but its contact with the Ganga- Kosi formation in sharp.

From the nature of the clastic ratio the alluvial fill of the Jamui formation can be divided into three domains viz.

1- The domain of sediments derived from chhotanagpur group of rocks this domain is characterized by the presence of brown sub angular to sub rounded, moderately sorted quart-rich medium to coarse sand with very little mica.

2- The domain of sediments from the Kharagpur group of rocks the sediments of this domain occur as a rim around the Kharagpur hill mainly to the east of Kiul river, to the west of Khaira-Shikandra road, the west of Garhi-Khaira road. The alluvial fill of the domain comprises mainly silt and clay.

3- The domain of sediments deposited by the Ganga. T he alluvial fill of this domain is characterized by an overlapping alteration of sand, silt and clay.

2- KHAGARIA FORMATION

The alluvial fill of Khagaria terrace constitutes the Khagaria formation. The outcrops of this formation occur as detached patches of various shapes & sizes and occupy the highest elevation in the alluvial terrain to the north of the Ganga. The alluvial fill of this terrace, which covered by a pedalfer type of soil of varying thickness, is predomination sandy in the domain of the Kosi-Baghmati Gandak river whereas it is rich in silt & clay in domain of the Ganga. The outcrops are mostly seen in the "levee" areas whereas the younger sediments, which are very well observed in the area between parhara & Itmadi, cover major part of the silt plain & flood basin areas.

3- GANGA-KOSI FORMATION

The older flood deposits of the Ganga-Kosi, Burhi-Gandak, Baghmati & their tributaries & distributaries constitute the Ganga-Kosi formation. To the north of Ganga, these sediments were deposited on the unevenly eroded surface of Khagaria formation whereas to the south they are laid over the partially eroded uppermost alluvial fill of Jamui formation.

In the Ganga valley area, sediments, comprise an overlappin alteration of unoxidised very fine grey, micaceous sand & grey silt with thin lenses of dark grey semi-plastic clay in levee are grading laterally into an overlapping alteration of grey silt & grey to dark grey clay in the flood basin area.

In the domain of the Ganga, the thickness of this formation varies from one to ten meters and locally up to 20 m. (Roy et.al. 1980).

4- DIARA FORMATION

The Diara formation contains unconsolidated flood plain deposited of the present day rivers usually occurring at the present day rivers usually occurring at the elevation of 36m.Or less. It covers large areas in belt of the Ganga & Progressively lesser areas in Kosi & other rivers. The total thickness of this formation varies from less than a meter near its contact with the levee to over 25m. in the Khutwa and Taufir Diara area. In short the alluvial fill of this formation is essential the meander belt deposits of present day rivers and the accretion of sediments is continuing in some areas during monsoon floods.

CHAPTER-5

GEOMORPHOLOGY OF THE AREA

Geomorphological study of the district **Munger and Jamui**, Bihar was carried out to analysis varies geomorphological and drainage morphometry of the study area.

The study was carried by stereo model using black & white aerial photographs included in the part of latitudes 24^0 45′ to 24^0 55′ North and longitudes 85^0 55′ to 86^0 10′ East. The study falls in parts of SOI toposheet No. 72 L/1 and 72 H/13.

Munger district is divided into two unequal segments of very different physical features by the river Ganga, flowing from west to east in a meandering channel. The area to the north of the river Ganga is fertile but small in dimension about $1/5^{th}$ total area and has a terraced alluvial landscape shaped by the Himalayan & sub Himalayan rivers viz. The Ganga, the Kosi & its distributaries, the Begmati, the Burhi & Gandak. A major part of this area is low-lying & liable to inundation during monsoon the low-lying areas are replete with abandoned channels of the above rivers & swampy patches. The maximum and minimum elevation of the area is 41.08m to 34.10m above MSL respectively.

The area to the south of the river Ganga has a diverse landscape made up of the hills, the plateau, the undulating erosional plain followed by the terraced alluvial plain. Culminating into the channel of Ganga. The major hill tracts are:

1. The karagpur hills, which terminate into the Ganga near munger town & divides the valley area into two unequal segments.

2. The gideshwar hills.

3. The hills of jhajha-simultala-batia area along the nothen fringe of chakai plateau.

The terrain on either side of the eastwardly acutely Kharagpur hill tract descends in five broad steps from the Chakai plateau in the south to the channel of the Ganga (32m. above MSL) in the north.

The differences in the characteristics of the area on either side of the Ganga are well described by E. Lockwood a former collector of Munger in following words "The northern part is an extensive plain formed by rich alluvial soil brought down by the ever changing rivers, while the southern part consists of vast rice tracts & forests which cover the metamorphic hills extending for away into the central India from the town of Munger."

The rivers separates also the most conspicuous trees & plants while the Sal, Mahua, & Ebony are important trees in the south, the cultivated Mango & Sisam are the common trees in north, similarily rice is the main crop to the south, whereas wheat, Indian corn, millet, peas musturd, linseed, & custer seeds are the main crops to the north.

RELIEF – The area of the district to the south of the Ganga shows wide relief variation compared to that in the north, where the variations are on micro-level only. The area has been divided into nine relief classes, each of which has a definite pattern of land utilization.

1. The area of the highest relief, more than 300m above MSL, including the central part of Chakai plateau a highest parts of the ridge area the Jhajha- Batia, Gidheswar & Kharagpur hill tracts. The elevation of the undulating Chakai plateau area varies from 304m in the north to over 358m in the south. The elevation of the isolated hill features, rising 10m, to 220m above the plateau level, varies from 380m to 614m above MSL, the heights being Ghoranji (624.32m).

2. The next lower relief class, having the elevation of 230m to 300m above MSL. Covers highly dissected & plateau extended up to simultala & includes the upper catchments areas of the Ajay the banner the Kiul, the Sakri, the Badua, the Belharma Rivers. The other areas within this relief class are intermediate slopes of high ridges within the three hill tracts.

In the fringe area of chakai plateau the land utilization pattern is same as in the chakai plateau proper, whereas the hill area are normally covered by natural forests, locally replaced by plantations but there are some barrain & semi-barren area within the zone which can also be considered for afforestation. The settlement pattern & the intensity of soil erosion are same as in the highest relief area.

3. The nest relief area having the elevation between 150m to 230m above MSL constitutes fairly extensive & moderately dissected highly undulating higher level erosion plain (erosion plain) around kawakol, cheraiya, shamdih, nargano, belbaend & katura to the north of the jhajha-batia hills (in the eastern extension of the bihar mica belt).

4. The area having the elevation between 75m. to 150m. Above MSL covers even large areas from kailash ghhati eastward up khesar through khaira, sono, gideshwar, dig & belharna constitutes moderately dissected, gently undulating low level erosion plains with valley fill areas in middle gegime of rivers originating from chakai plateau, gidheshwar & kharagpur hill.

5. The area between the elevations 60m. to 75m. Above MSL constitute the southern part of the gently undulating high level alluvial plains, which is locally dissected & extend eastward from baroigh to tarapur through sheinkhpura, billo, tetarhat, kajra, bengalwa, thereafter skiting the northern & eastern part of the kharagpur hills as a narrow & then again widens & extending from kharagpur haveli eastward up to tarapur & beyond. The major part of this tract is under cultivation, the effectiveness of which can be increased with better surface water irrigation. The barran area is mostly in the transition sone with the next height relief class, particularly in the periphery of Kharagpur hills & around the inliers within the valley.

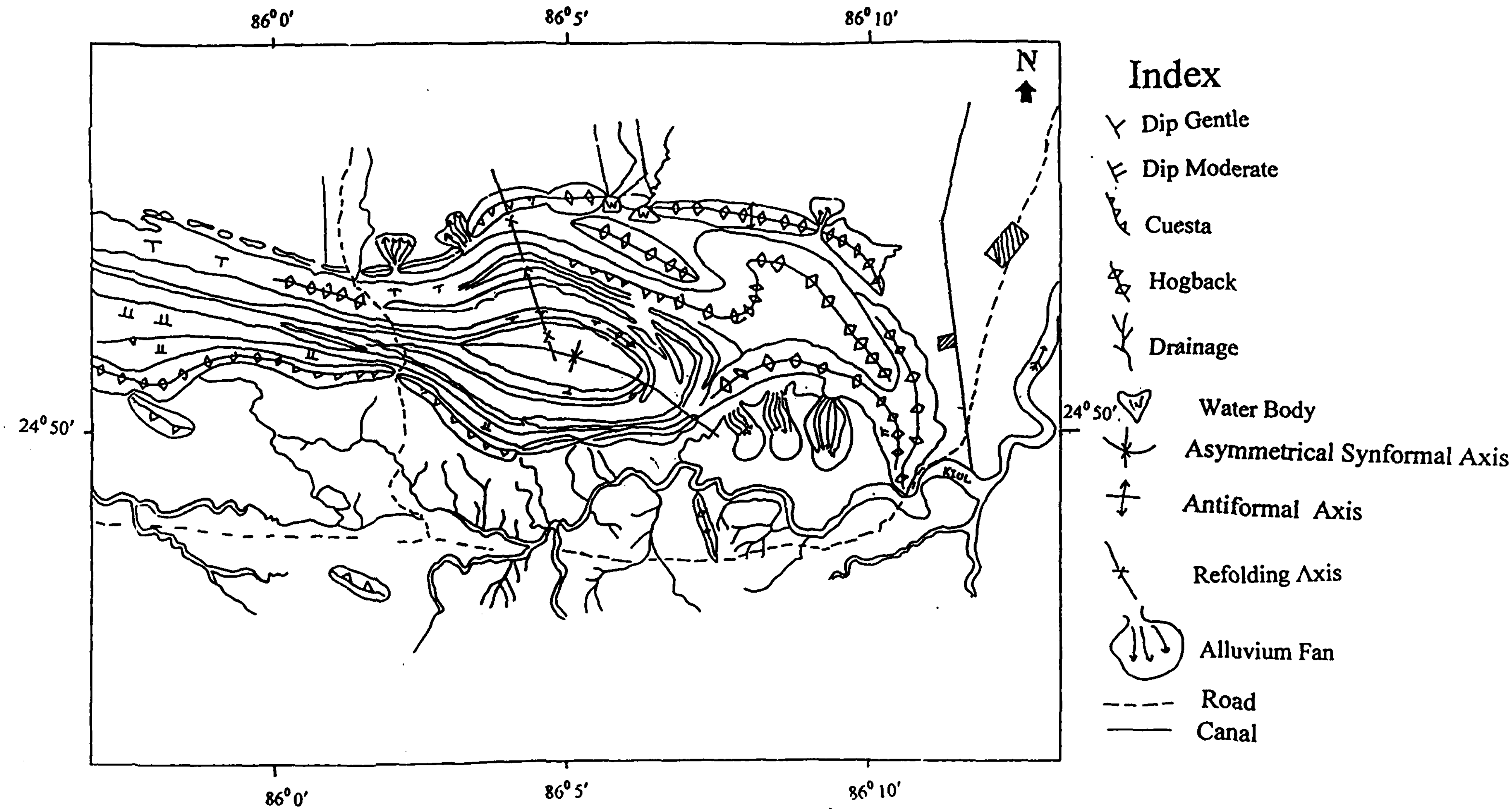
6. The next lower relief area having the elevation between 45m to 60m. MSL includes the northern peripheral part of the high level alluvial plain Jamui terrace with defined zone between the high level & the intermediate alluvial terrace to the south Ganga.

7. The area having the elevation between 40m. & 45m. Above MSL constitute the higher grounds within the intermediate alluvial plain to south of the Ganga. The relief zone cover fairly large area between Mehuns & Surajgarha in the lower reaches of Kiul River.

8. The area having the elevation between 37m. & 40m. Above MSL covers the relatively higher parts of the vast alluvial plain to north of the Ganga and also the major part of intermediate & low-level alluvial plain area to south of the Ganga.

9. The lowest relief area in the entire district has elevation between 34m. & 37m. above MSL. It represents the core area of back swamp depression to the south of the Ganga & cover, intensive area to north of the Ganga, where water logging & recurring annual flood are very common.

GEOMORPHOLOGY & STRUCTURES OF THE AREA.



Geomorphic classification of the terrain

The componential geomorphic unit of the Munger and Jamui Area has been mapped under the stereomodels on the basis of homogeneity of tone, texture, and drainage patterns, lithological characteristics of the area. The unit recognized on the area can be classed as erosional and depositional. The study was directed to evaluate the geometry of the landforms through. Convergence of photo recognition and terrain elements. Dynamics of the evolutionary process was interpreted considering local sectors.

Structural Hills

In space images and aerial photograph the structural hills are characterized medium to dark gray photo tone, fine texture and very coarse textural dendritic and sub-dendritic drainage with gentle V- form valley profile.

The spatial spread of the structural hills in the area roughly coincides with the spatial deposition of Quartzite and Mica Schists. Gidheshwar pahar, Gambhira pahar, Narela pahar, Murli pahar, Charki pahar, Dhamna pahar, Deoasthan pahar, Burwa pahar, Batia pahar, Sandela pahar and Basanth pahar reserve represents these hills forest.

Structural Valleys

The drainage in the area is controlled by spatial spread of open, shallow synclines, which provide ready-made channels for surface runoff. Their characteristic features of structural valleys in the area have been rectilinear of trend and at time their convergence with erosive channels at non-accordant levels. Structural valleys of the south of the Basanth pahar Reserve forest are observing trending EEN-SSW.

Erosional Hills

Generally, erosional hills are characterized by medium to light photo tone, moderate texture. Erosional hills are residual hills of the regional structural hills are consist of loose sediments. Some erosional hills occur in many places like in adjoining areas of Kuil Nadi and near Nata Nadi.

Cuestas

In the weathered gneisses and schist wherever the dips are low, the metamorphosed lithology have been carved out into ridges with asymmetric profiles. The obsequent slopes are steep and short. These features are characterized as cuestas in central and Southern part of Basanth Pahar.

In space images and in aerial photographs the cuestas have been recognized by rectinearity of the structural trends and asymmetry of slopes. Steeper slopes being short and gentler slopes being ling, the texture of the steep slopes is generally rough and tone is dark.

Along gentle slopes in cuestas the tone is light and texture is smooth. The spatial continuity is generally punctured by consequent drainage in the areas.

Hogbacks

In the areas like Gidheswar, Dhamna, Sandela and Doesatana reserve forest, the basic ridges with a nearly symmetrical profile are seem. The slopes of the ridges have moderate gradient. The gentle angle of the slope roughly coincides with the depth of the strata in the area. The continuity of the structural trend has been broken by local drainage, which cut across the strike. The hogbacks in space images are like cuestas but are separated by the near uniformity of consequent and obsequent slopes, symmetry of profile relatively slopes and shorter slopes along the profile.

Pediment

Smooth rocks cut slopes at the base of structural hills in the area near Gidheshwar, Deoasthan, Sandela, Murli and along Kuil Nadi, Nata Nadi all have been mapped be a pediment. The surface has been cared out of the basic rocks in area. The out crop density on he pediment surface is low. The erosional surface is generally carved be a thin cover of soil. The pediments have been recognized by low relief, darker photo tone than the adjacent hills and sub-dendritic drainage pattern.

Escarpment

Along, more or less continues cliff or relatively steep slope in one general direction, separating two level or gently sloping surfaces, and produced by erosion or faulting is referred as escarpment.

Pediplain

A broad gently sloping erosional surface or plain of low relief receding mountain front is designated as pediplain. It is underlain y bed rock that may be bare but is more often covered be a thick discontinuous cover of alluvium, derived from the upland masses and in transit across the southern part of the Gidheshwar and Northern part of the Sandela in parts of Jamui.

CHAPTER – 6

STRUCTURES & LINEAMENTS OF THE AREA

The pre-Quaternary rocks of Munger particularly the Chhotanagpur group have undergone multiple phase of deformation, resulting in a complex pattern of diastrophic structure (Gaha et al 1980). Even then some non-diastrophic structures are also recognizable in these rocks.

Folds

In the study area the folds are doubly plunging folds, which have the shape antiformal and synformal the trend of the folding, is NE-SW.

Joints

The prominent joints observed in the granite gneisses and Quartzites are: 1. Strike joints trending WNW-ESE to NW-SE. 2. Dip joints trending NS-NNE-SSW. 3. Oblique joints whose dip and strike are variable.

Fault

The normal fault is present in the study area. The trending of the fault is NW-SE.

LINEAMENTS AND ITS DENSITY MAPS

Lineaments, being surface manifestations of structurally controlled linear or curvilinear or features, are identified in the satellite imagery by their relatively straight tonal alignments. A lineament is defined as large-scale linear feature, which expresses itself in terms of topography of the underlying structural features. Lineaments can be joints, fractures, dyke systems, straight course of streams and vegetation patterns. In hard rock terrains lineaments represent area and zones of faulting and fracturing resulting in increased secondary porosity and permeability. They are good indicators for the accumulation and movement of groundwater. Lineaments provide the pathways for ground water movement and are hydrogeologicaly very important (Sarkar et. al., 1996).

The ground water abundance in hard rocks depends not only on rocks type but also on the intensity of tectonic activities. The store capacity of a hard rock aquifer of complex nature is low as the rock itself is impervious. In this context mapping of fracture and lineaments give a clue to the occurrence of the ground water in hard rock terrain. Since the advent of remote sensing technology, various workers have emphasized the importance of satellite images in structures analysis (Blanchet 1956-57, Mollard 1957-59, Henderson 1960, Huan 1961, Bakliwal 1978, Ramaswamy 1985, Mukherjee et al 1988, Ali 2000-2001).

So far, two groups of lineaments, each comprising a system of en echelon faults have been recognized in Munger and adjoining areas to the south of the ganga. Theses are identified and interpreted from the IRS imagery and aerial photographs.
The lineaments of the first group located in the Kharagpur hills as well as in Chandan, Badua, Kiul, Sakri, Tilaiya, Batane and N. Koel rivers are truncated and/or laterally displaced by the E-W trending lineament of the second group. They are trends varying from N-S in the eastern part to NW-SE in the western part of the Ganga valley area. They are affecting the pre-Quaternary rocks and sustain the hot springs. In the Kharagpur hills, Chakai plateau and adjacent areas indicate intense fracturing, development of slickensides and silicification of the brecciated rocks along the faults are locally parallel to that of fold axis.

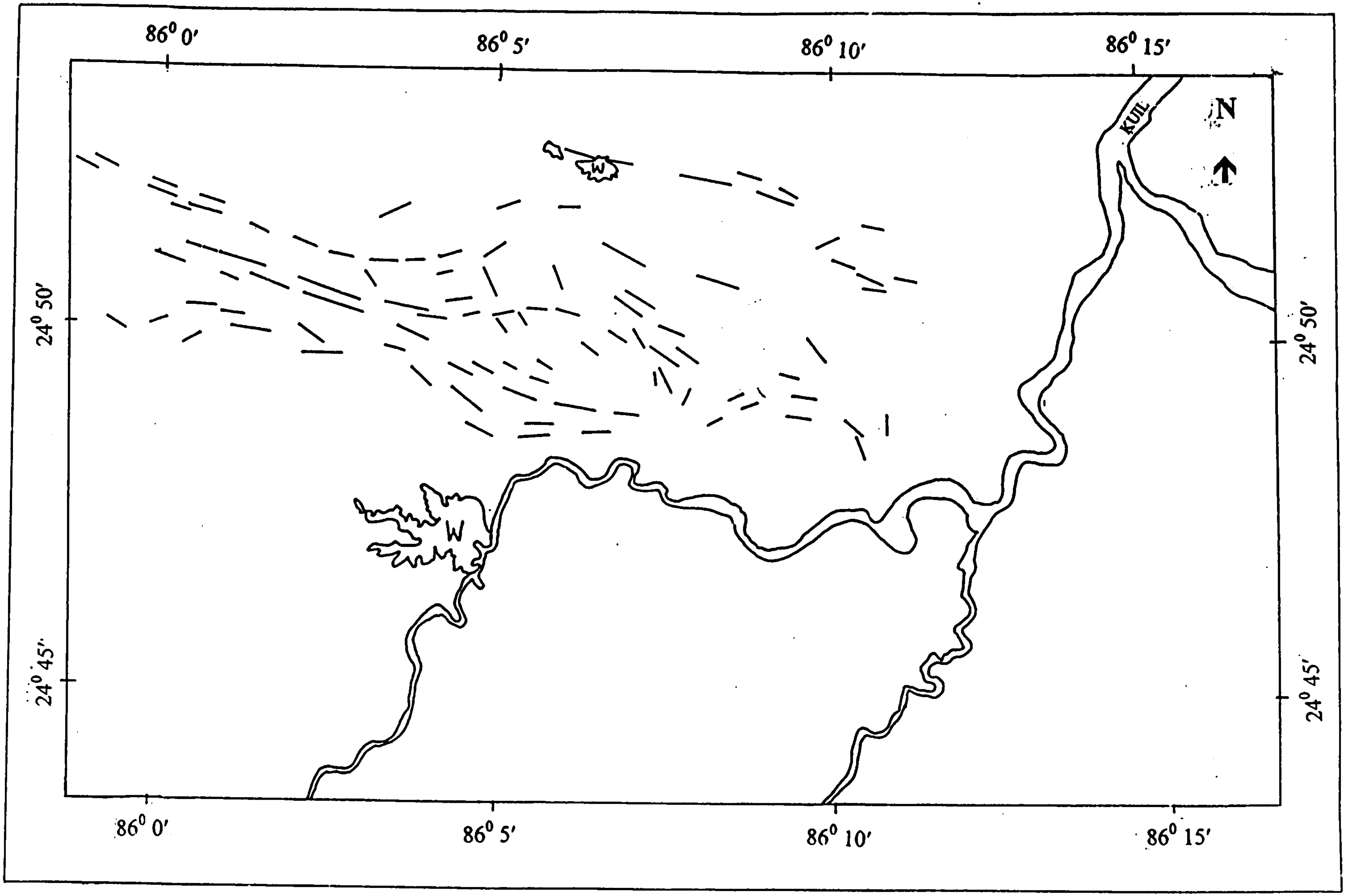
The lineaments of the second group have two components, viz.

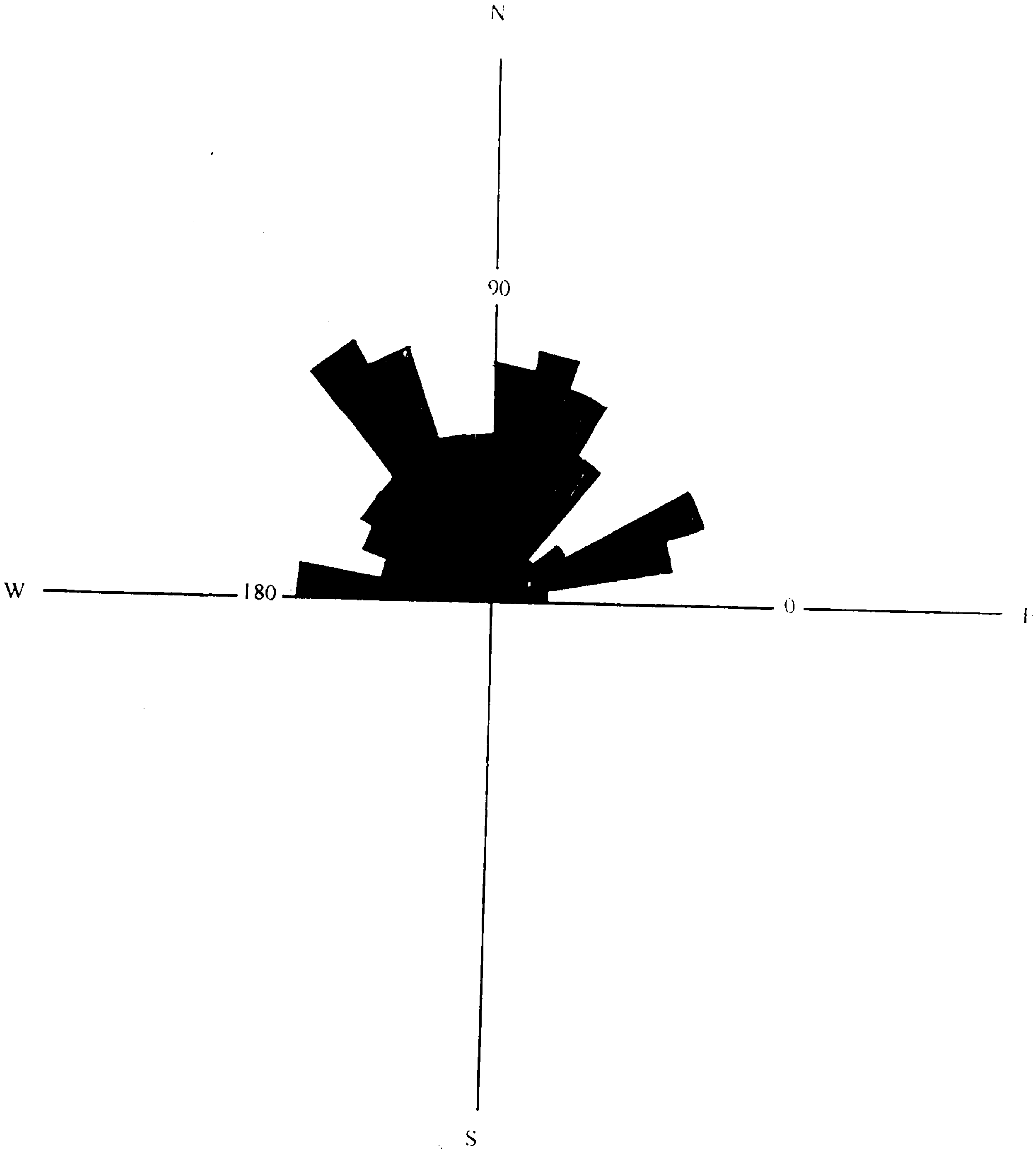
- E-W trending faults along the course of the Ganga.
- ENE-WSW trending faults along the margin to the Chhotanagpur upland restricting the southern limit of the basin.

Lineament density map is a measure of quantitative length of linear feature expressed in a grid. Lineament density of an area can indirectly reveal the groundwater potential of that area since the presence of lineaments usually denotes a permeable zone. Areas with high lineament density are good for groundwater development (Haridas et. at. 1994, Haridas et. al. 1998).

The lineament map shows that the NE-SW, NW-SE and NNE-SSW are the dominant lineament trends in the Jamui area. These have a strong control on the drainage system of the basin. A majority of the lineaments fall between 0^0-40^0 NE and 10^0-40^0 NW.

LINEAMENTS STUDY OF THE AREA





Rose diagram showing Frequency diagram for Azimuth distribution of Lineament

Table1. Data showing total number, total length and average length for each azimuth class lineament orientation based on drainage.

Azimuth class	Total number
0-10 NE	4
10-20 NE	13
20-30 NE	16
30-40 NE	6
40-50 NE	4
50-60 NE	12
60-70 NE	16
70-80 NE	18
80-90 NE	17
0-10 NW	12
10-20 NW	19
20-30 NW	21
30-40 NW	11
40-50 NW	11
50-60 NW	10
60-70 NW	8
70-80 NW	14

CHAPTER-7

MORPHOMETRIC ANALYSIS OF THE AREA

1-Stream Order: - For ordering the stream, the system introduced by Horton R.E. (1945) and data slightly modified by Strahler, A.N. (1962) has been followed.

Streams up to five orders are present in watershed. Assuming that one has available a channel network map including all intermitted & permanent flow line located in a clearly defined valleys the smallest fingertip tributaries are designated Order1, are the first order where two first order channels join a channel segment of Order2, is formed where two of the 2nd order join a segment of order 3rd is formed & so forth.

2-Stream Number: - The low of stream number was introduced by Horton (1945) which states that the number of stream segments of each order form an inverse geometric sequence with order number.

3-Bifircation ratio: - It is obvious that number of stream segments of any given order will be fewer than for the next lower order. But move numerous than for next higher order. The ratio of a given order Nu to the number of segment of the higher order Nu+1 is termed the bifurcation ratio Rb.

$$Rb = \frac{Nu}{Nu+1}$$

The lower bifurcation ratio values are characteristics of watershed. Which has suffered less structural disturbances and the drainage pattern has not been distorted by the structural disturbances. The Rb is inductive of shape of the Basin also.

An elongated basin is likely to have high (Rb) whereas a circular basin is likely to have low (Rb).

3- **Stream Length:** - LU channel length is measured with the chart meter (map measure) directly from the map and therefore represents the true length. To obtain the mean length of channel Lu of order u the length is divided by the number of segments Nu of that order

$$Lu = \frac{En\ Lu}{Nu}$$

<u>A REAL ASPECT OF DRAINAGE BASIN</u>

1- **Basin shape:** - The shape of basin affects stream flow hydrograph and peak flows. The important parameter describes the shape of basin Form factor (Rf), Circulatory ratio (Rc), Elongation ratio (Re).

Form Factor (Rf) - Horton (1932) has introduced this term Quantitative expression of drainage basin outline form made by Horton through a from factor which is dimensionless ratio of basin area. Au to the square of the basin length Lb this:

$$\mathbf{Rf} = \frac{\mathbf{Au}}{\mathbf{Lb}}$$

The value of the form factor would be always being less than 0.7854 for a perfectly circular basin. Smaller the value of the form factor more elongated is the basin the basins with high form factor have a flatter peak of flow for long duration flood flows of elongated basins are easier to omanage than of the circulator basins.

Elongation ratio: - Schumm, S.A. (1956) has introduced the elongation ratio as the diameter of a circle of the same area as the basin to maximum basin length. This ratio runs between .06-1.0 over a wide variety of climatic & geologic types. Values near to 1.0 are typical of regions of very low relief where as values in the range 0.6-.08 is generally associated with strong relief & steep ground slopes.

$$\mathbf{Re = 2/Au/Lu}$$

Where Au = Basin area (km^2)
Lb = Max. Length of the basin (km)

Circulatory ratio (Rc): - Miller (1953) used a dimensionless circulatory ratio defined as the ratio of basin area (Au) to the area of a circle having the some circumferences as the perimeter of the basin. He found that circulatory ratio remained remarkably uniform in the range 0.6-0.7 for first & second order basins in homogenous shale & dolomites indicting the tendency of small drainage basin in homogenous geologic to preserve geometrical similarity.

$$\mathbf{Rc = 4.Au/P^2}$$

Where P = Perimeter of the Basin (km)
Au = Area of the basin (km^2)

2. Drainage Density (Dd): - According to Horton (1932) the drainage density is obtained by dividing by the total stream length to total basin area accordingly:

$$Dd = L/Au$$

Where L = Total length of stream (km)
Au = Area of the basin (km^2)

The lowest values between 3.0-4.0 miles/sq miles are observed in the resistant sand stone.

The low drainage density is observable in the regions of highly resistant a highly permeable sub soil materials particularly in the area of thick vegetative cover with no relief where as high drainage density is indication of week or impermeable sub subsurface materials mountainous relief & sparse vegetation. Thus drainage density is controlled by various factors. Such as lithology compactness of the surface, vegetation covers relief etc.

3- Stream Frequency: - It is the total number of streams in drainage basin divided by the area of the drainage basin. Stream frequency can be obtained by dividing the total number of streams in a given basin to the area table's show the numerical values of the stream frequency.

Stream frequency (F) as the number of the stream segments per unit area

$$F = \frac{N1+N2-1}{A}$$

(N1 + N2 -1) is the total no. of segments of all orders with in given basin.

4- Basin Relief: - Relief 'H' is the elevation difference between reference points defined in a region of a given boundary is simply the elevation difference between highest and lowest points.

5- Relief Ratio: - When basin relief 'H' is divided by the horizontal distance on which it is measured there results a dimension less relief ratio (Rh). Taking vertical & horizontal distances as legs of a right triangle relief ratio is equal to the tangent of the lower acute angle & identical with the tangent of angle of slope of the hypotenuse with respect to horizontal.

$$Rhp = 100H/5280P$$

Where P = Perimeter of the Basin (km)
H = Max.Basin relief in feet.

6. - Constant of channel maintenance (CM): - Schumm (1956) used the inverse of drainage density as a properly termed the constant of channel maintenance (c) which may be simply defined as the area of basin surface needed to sustain a unit length of stream channel. The constant (c) is expressed an sq km/km, as depends upon regime vegetation cover & relief but also the duration of erosion & climatic history. The constant is extremely low in areas of close dissection.

7-Drainage texture: - An important geomorphic concept is drainage texture by which we mean the relative spacing of drainage lines. Horton (1945) has pointed out that we commonly refer to as drainage texture really includes both drainage density and stream frequency.

8-Infiltration number: - The infiltration number is the produce of density and stream frequency. It plays significant in observing the infiltration character of the basin. It is inversely proportion to the infiltration capacity of the basin.

9- Length of overland flow: - This term was used by Horton (1945) which is one of the most important independent variable by virtue of which the hydraulic and physiographic developments of drainage basin is affected Horton has taken approximately equal to the half of the reported of density thus:

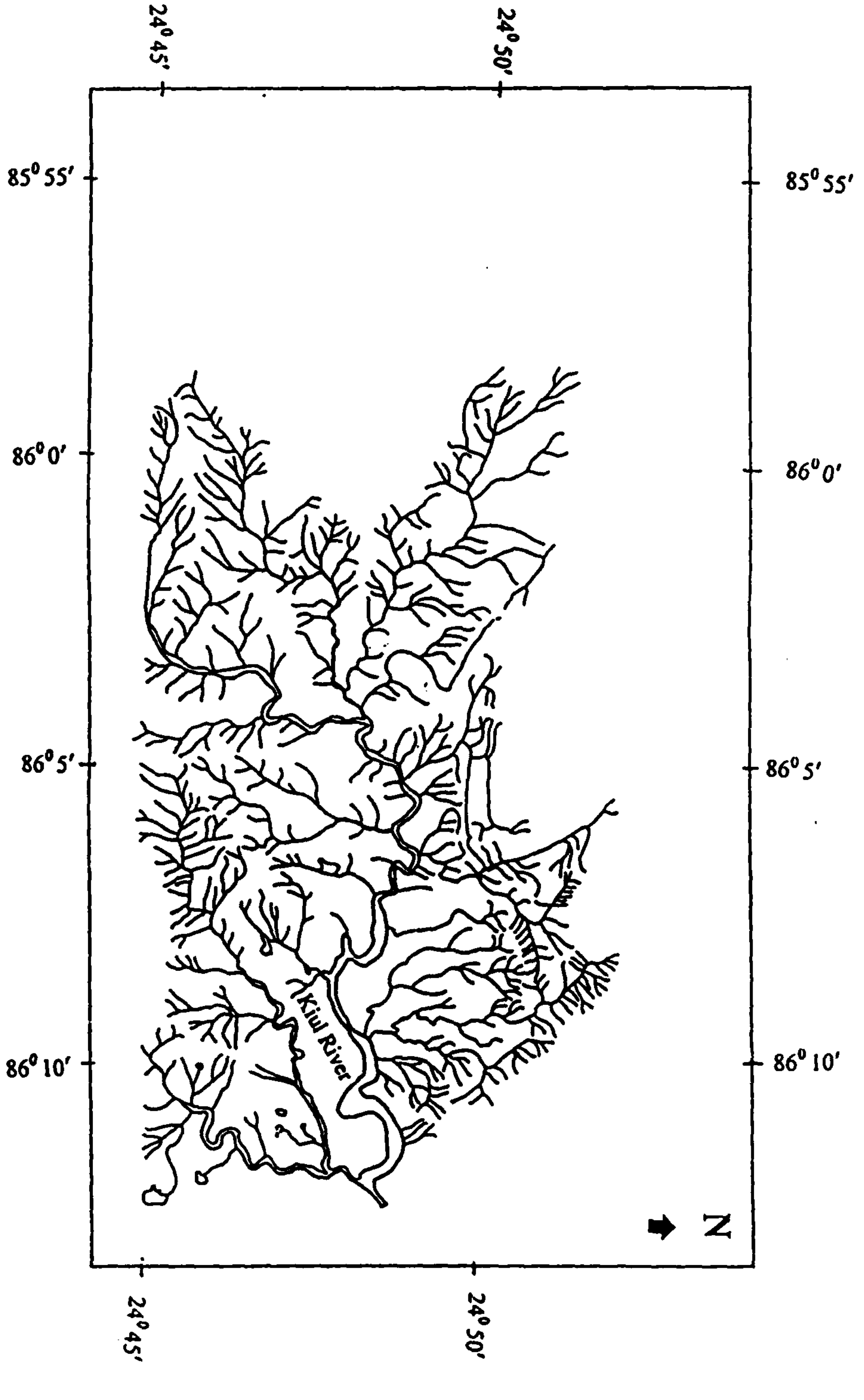
Length of overland flow Lg = ½ Au/L.

10- Ruggedness & Geometry Number: - Ruggedness number is the product of maximum basin relief and drainage density (Strahler, 1964) where both terms are in same units.

The dimensionless property of slope can be introduced into the ruggedness in the following way consider that the adjacent stream channel is equal to about one half the reciprocal of the drainage density and that local relief 'H' is measured as the vertical drop from divide to adjacent channel. Thus the slope 'Sg' the ground surface from divide to stream will be related to 'H' 'D' by the equation:

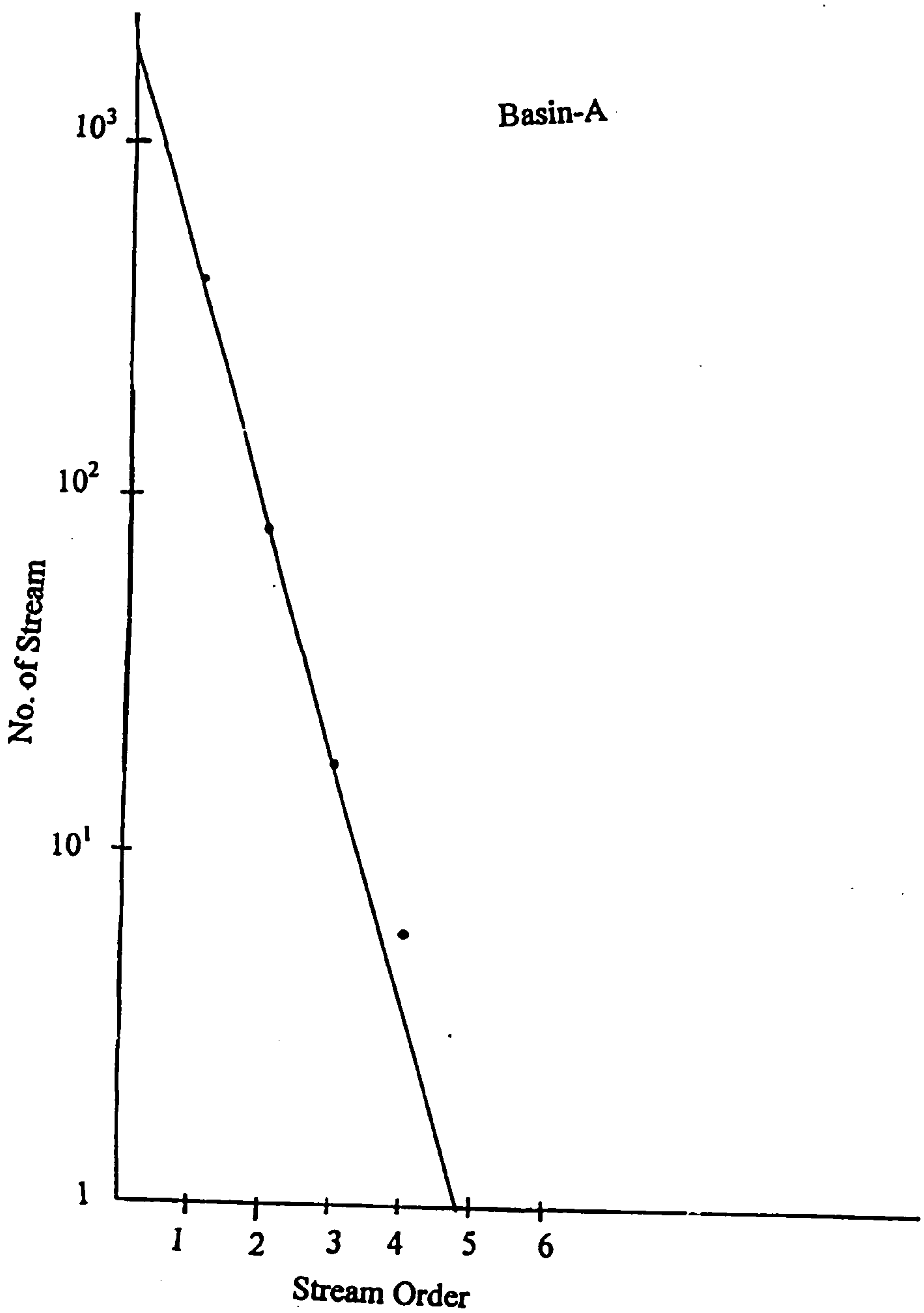
Sg =H X 2D

Where Sg = Tangent of the ground slope HD/Sg = ½

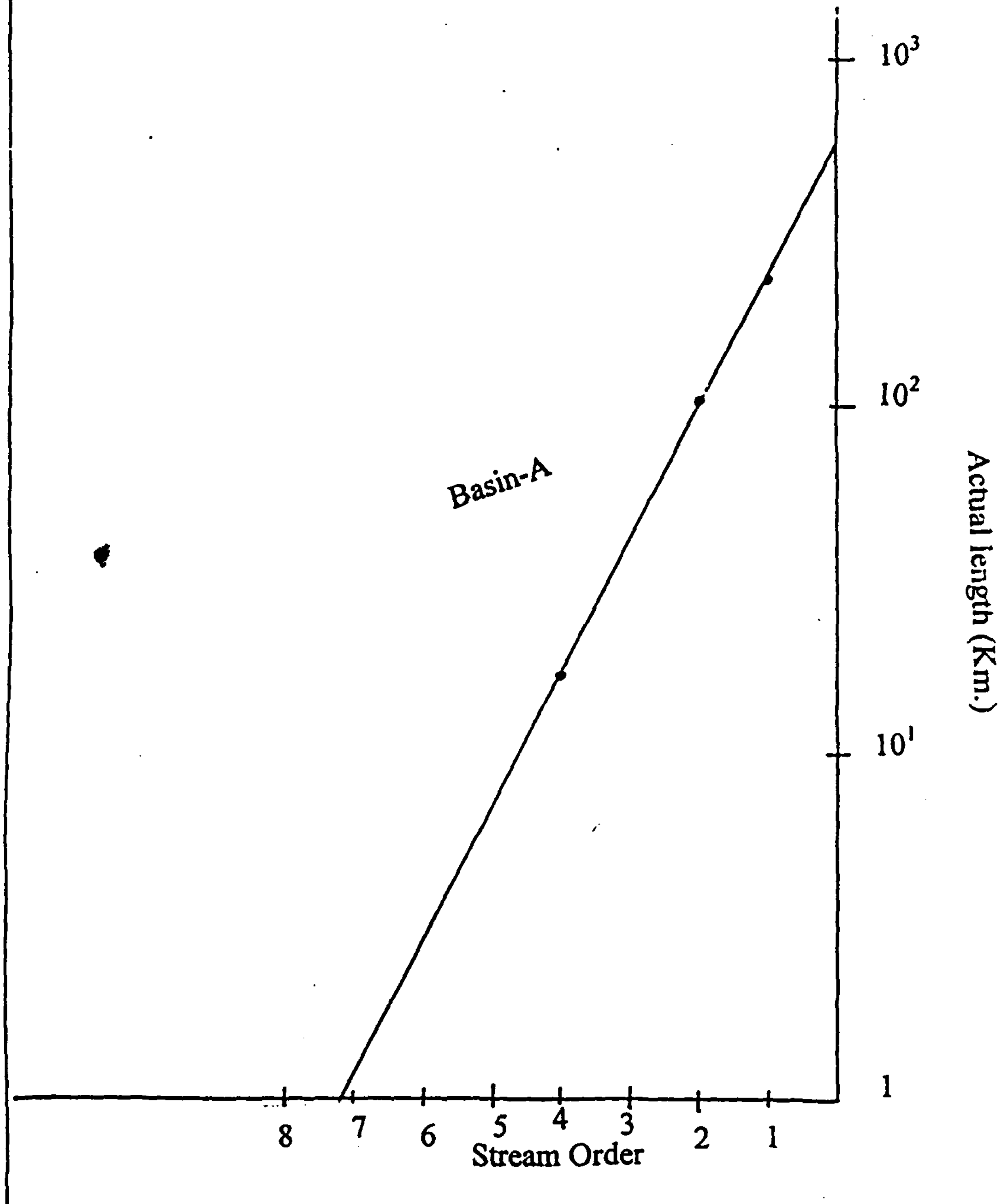


Kiul Basin-

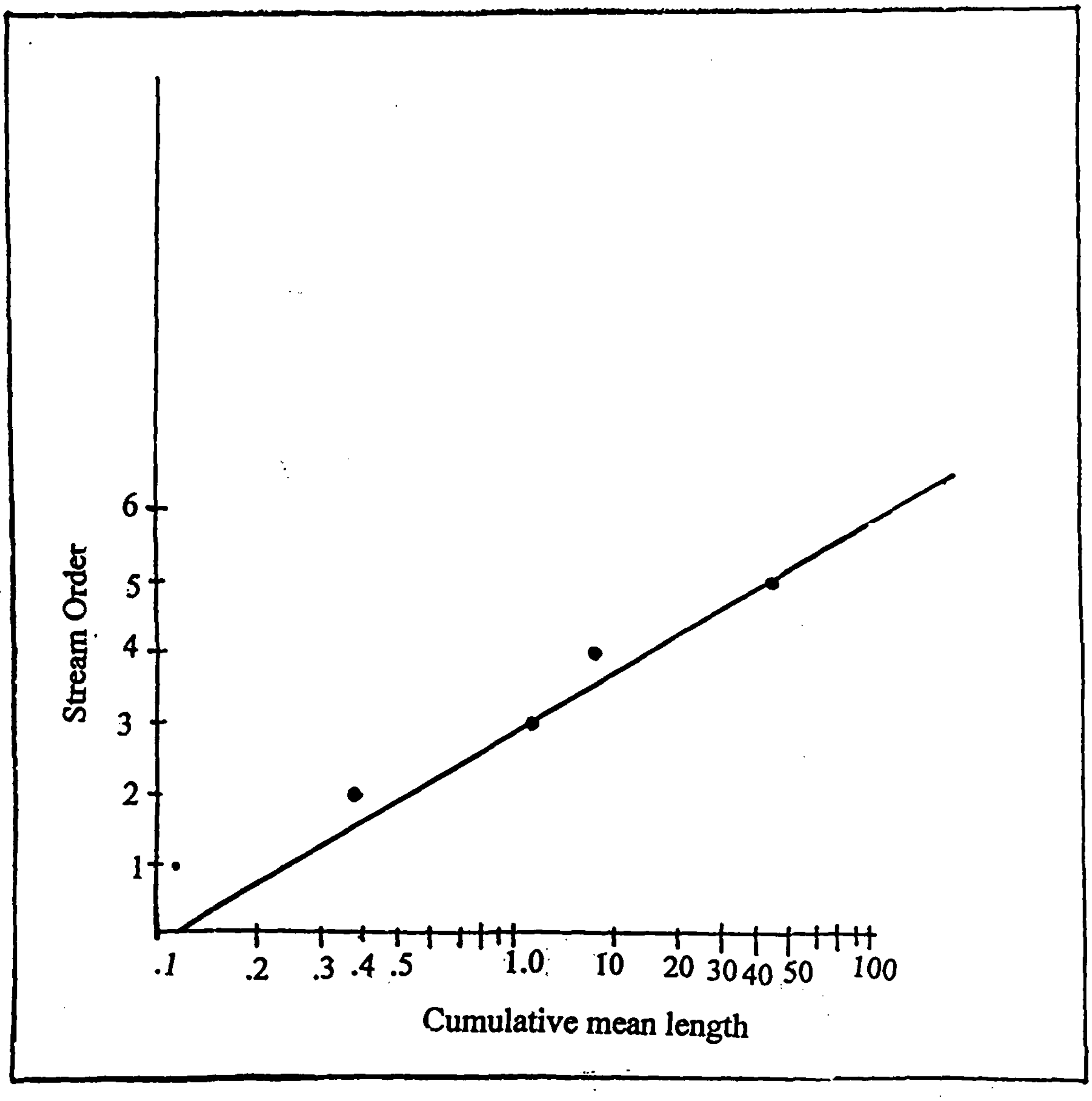
Drainage Basin of Kiul River (Morphometric Analysis of the Kiul Basin) of the Jamui district, Bihar.



Relationship between No. of Streams & Stream Order



Relationship between Actual length and Stream Order



Stream Order
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1.0
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20
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40
50
100
Cumulative mean length

Table2: Methodology adopted for computation of morphometric parameters.

Sl. No.	Morphometric Parameters	Formulas	References
1.	Stream order	Hierarchical rank	Strahler (1964)
2.	Stream length (Lu)	Length of the stream	Horton (1945)
3.	Mean stream length (Lsm)	Lsm = Lu / Nu Where, Lsm = mean stream length Lu = total stream length of order 'u' Nu = total no. of stream segments of Order 'u'	Strahler (1964)
4.	Stream length ratio (RL)	RL =Lu / Lu-1 Where, RL = stream length ratio Lu = the total stream length of its next lower order Lu-1 = the total stream length of its next lower order	Horton (1945)
5.	Bifurcation ratio (Rb)	Rb = Nu / Nu + 1 Where, Rb = bifurcation ratio Nu = total no. of stream segments of order 'u' Nu + 1 = number of segments of the Next higher order	Schum (1956)
6.	Mean bifurcation ratio (Rbm)	Rbm = average of bifurcation ratios of all orders	Strahler (1957)
7.	Relief ratio (Rh)	Rh = H / Lb Where, Rh = relief ratio H = total relief (relative relief) of the basin in kilometers Lb = basin length	Schum (1956)
8.	Drainage density (D)	D = Lu / A Where, D = drainage density Lu = total stream length of all orders A = area of the basin (km^2)	Horton (1932)
9.	Stream frequency (Fs)	Fs = Nu / A Where, Fs = stream frequency Nu = total no. of streams of all orders A = area of the basin (km^2)	Horton (1932)
10.	Drainage texture (Rt)	Rt = Nu / P Where, Rt = drainage texture Nu = total no. of streams of all orders P = perimeter (km)	Horton (1945)

11.	Form factor (Rf)	Rf = A / Lb^2 Where, Rf = form factor A = area of the Basin (km^2) Lb^2 = square of basin length	Horton (1932)
12.	Circulatory ratio (Rc)	Rc = 4 * Pi * A / P^2 Where, Rc = circulatory ratio Pi = 'pi' value i.e. 3.14 A = area of the basin (km^2) P^2 = square of the perimeter (km)	Miller (1953)
13.	Elongation ratio (Re)	Re = 2 v (A / Pi) / Lb Where, Re = elongation ratio A = area of the basin (km^2) Pi = 'pi' value i.e. 3.14 Lb = basin length	Schum (1956)
14.	Length of overland flow (Lg)	Lg = 1 / D * 2 Where, Lg = length of overland flow D = drainage density	Horton (1945)

Morphometric Analysis of the Kiul Basin

Order of stream	**Total no.of streams of individual order**	**Bifircation ratio**
1^{st} Order	430	5.38
2^{nd} Order	80	4.21
3^{rd} Order	19	3.16
4^{th} Order	6	6.00
5^{th} Order	1	-
	$\sum$ = **536**	

Order of stream	Total length of streams of individual order (cm)	Actual length (Km)
1st Order	500	250
2nd Order	210	105
3rd Order	165	82.5
4th Order	32	16
5th Order	38	19
		$\sum$=472.5

Order of stream	Length ratio	Actual mean length (Km)	Cumulative length
1st Order	0.42	1.16	1.16
2nd Order	0.78	2.62	3.78
3rd Order	0.19	8.68	12.46
4th Order	1.18	5.33	17.79
5th Order	-	38	55.79

Area of basin **Cm2 km^2**	**Drainage density**	**Basin perimeter (Km)**
1037 259.25	$\frac{472.5}{259.25} = 1.82$	85

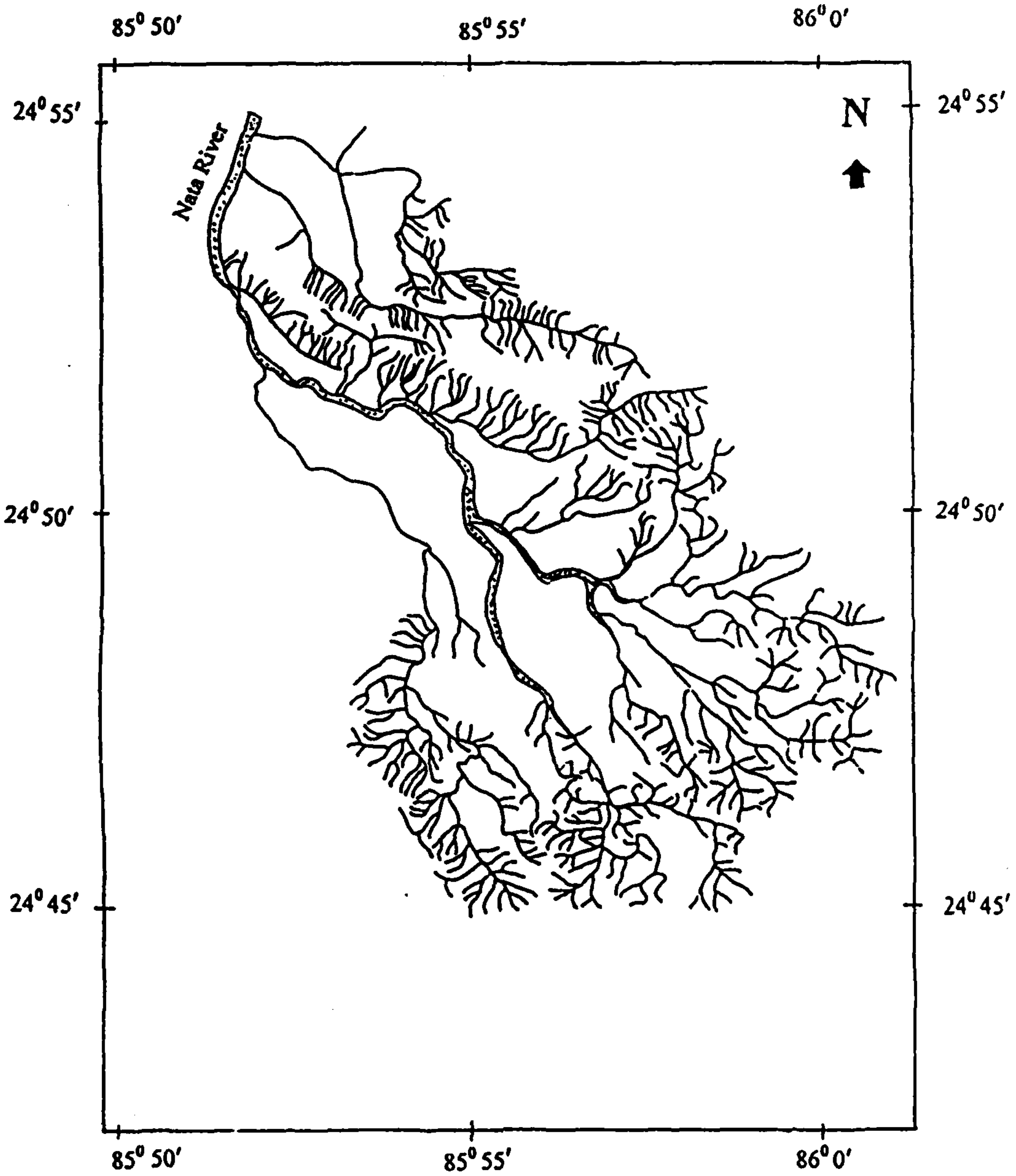
Max.basin length (km2)	**Basin relief (m)**	**Relief ratio**
27	337	275.5

Stream frequency	**Form factor (Rf)**	**Elongation ratio**
2.07	0.355	2.857x 10-4

Circulatory ratio (Rc)	**Infiltration no.**	**Length of overland flow**
0.143	3.86	0.274

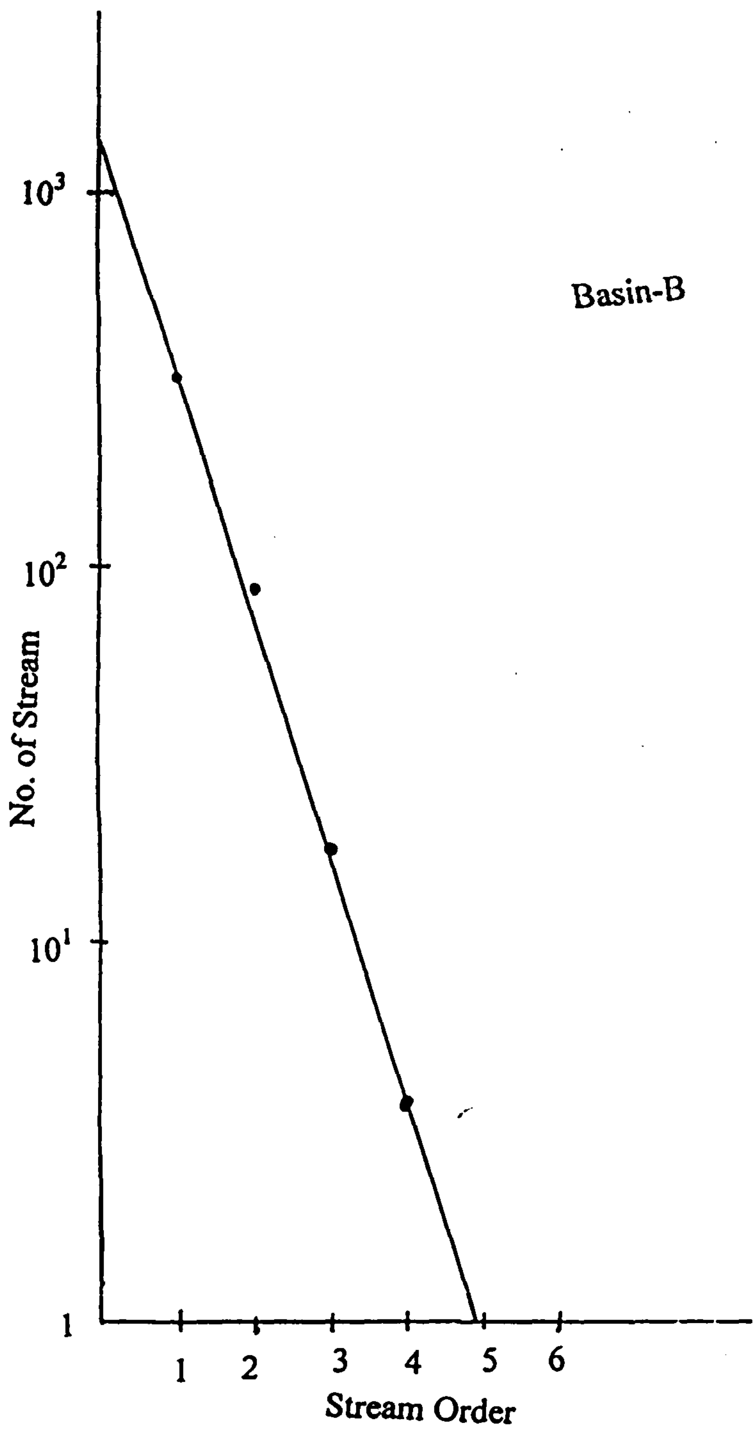
Max.basin relief	**Relief ratio**	**Relative relief ratio**
551m.	0.611	$\frac{100\,H}{P} = 0.648$

Ruggedness no. (HD)	**Constant of channel maintenance (CM)**
1.030	0.549

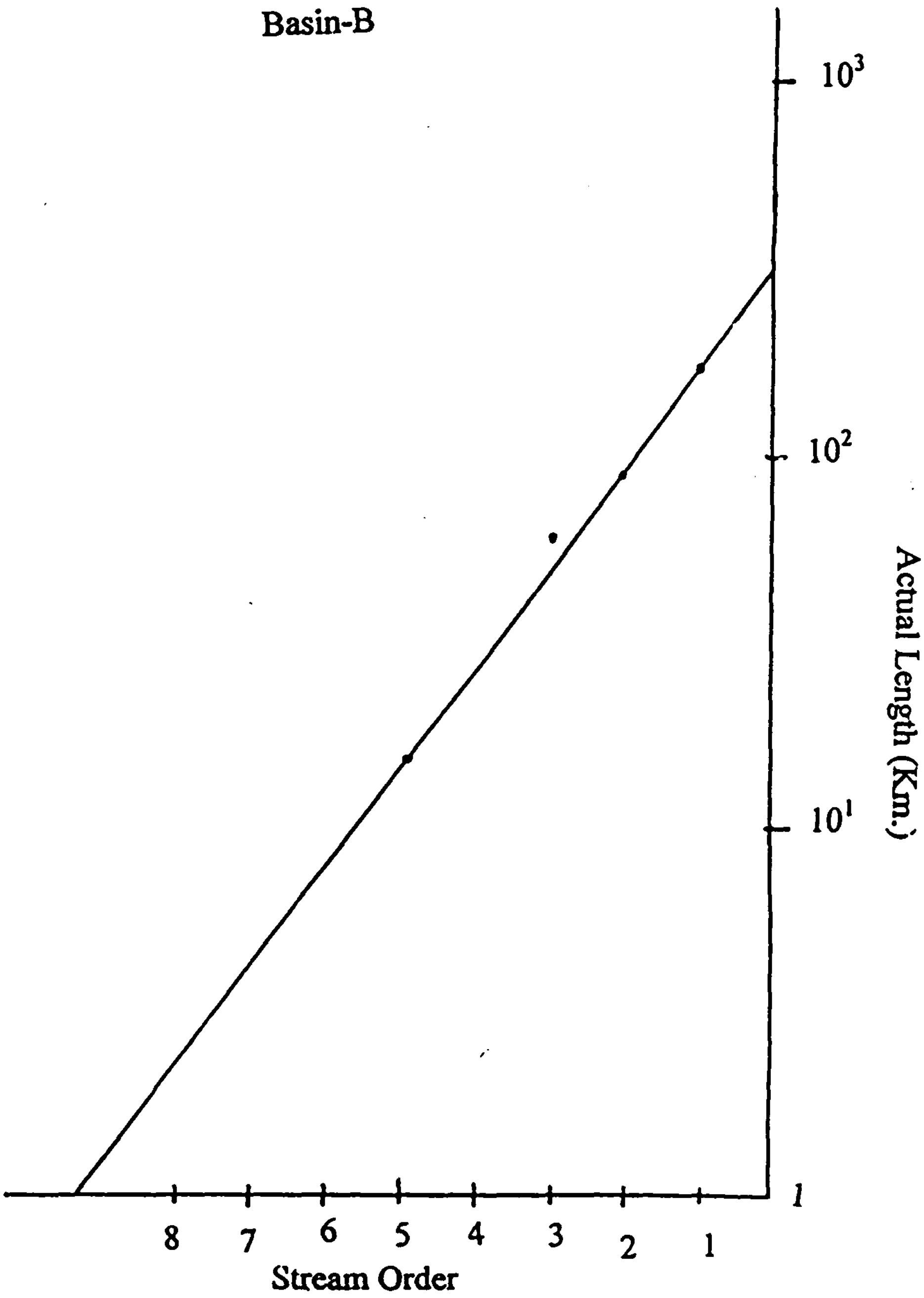


Nata Basin-

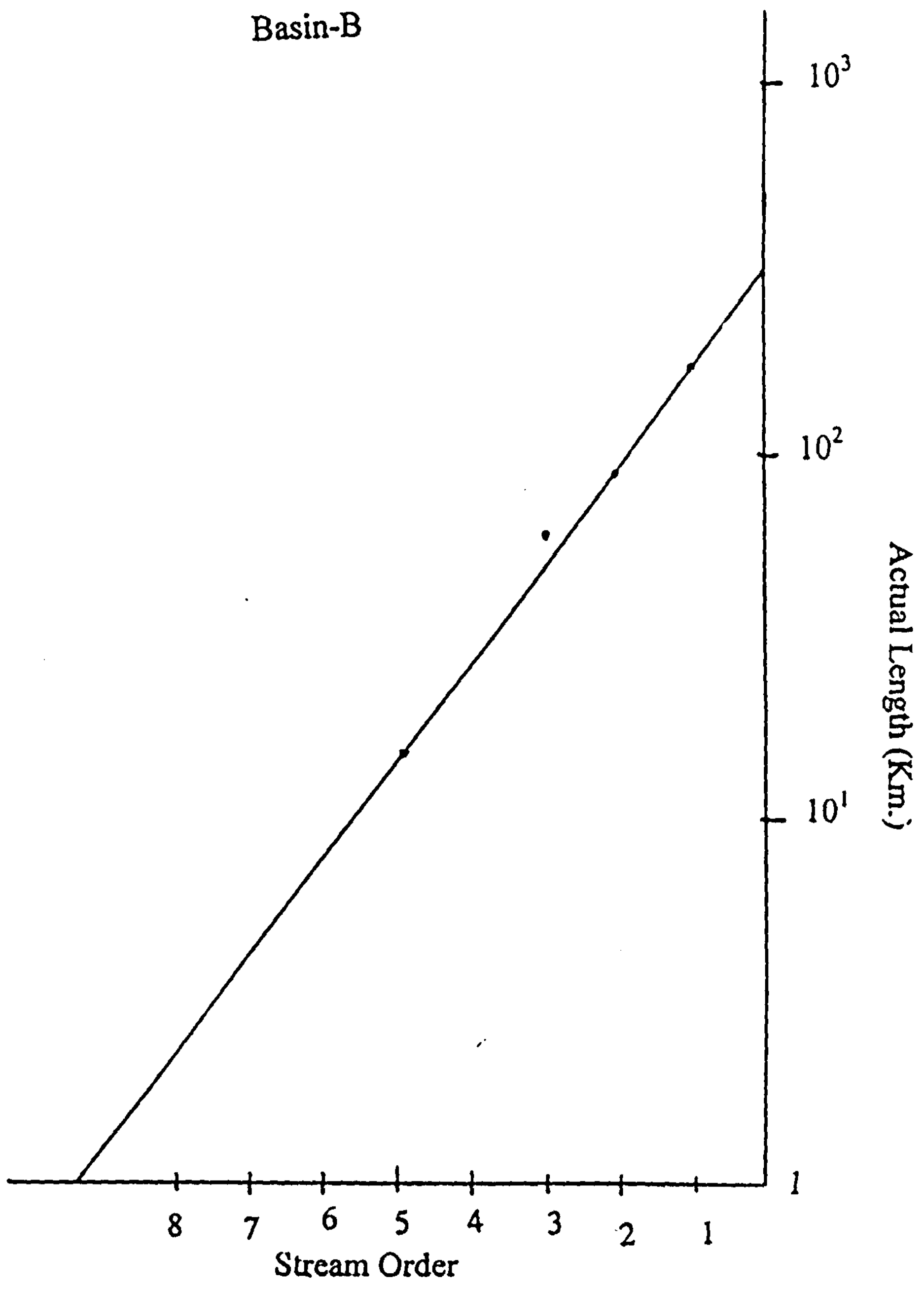
Drainage Basin of Nata River (Morphometric Analysis of the Nata Basin) of the Jamui district, Bihar.



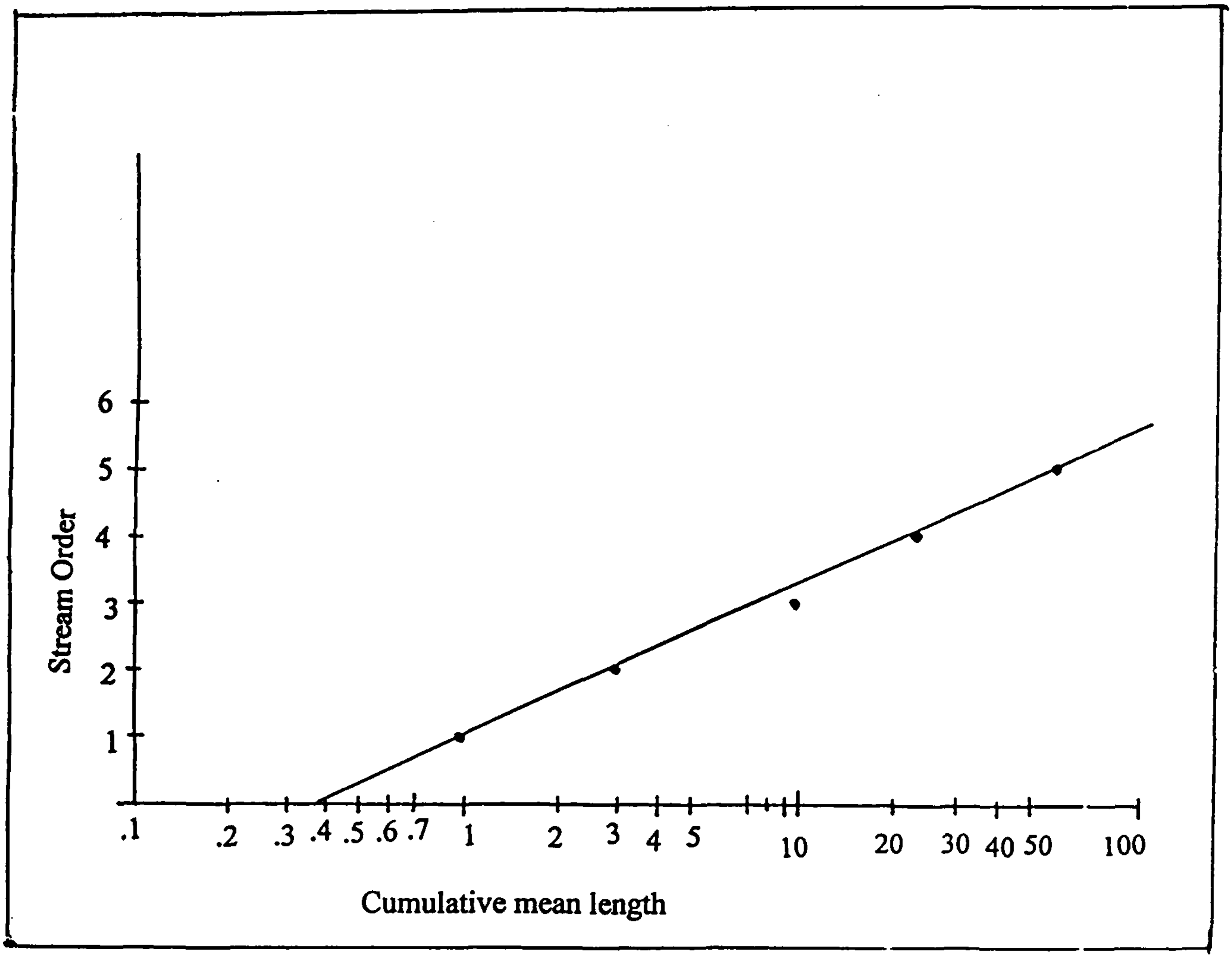
Relationship between No. of Streams & Stream Order



Relationship between No. of Streams & Stream Order



Relationship between Actual Length & Stream Order



Stream Order
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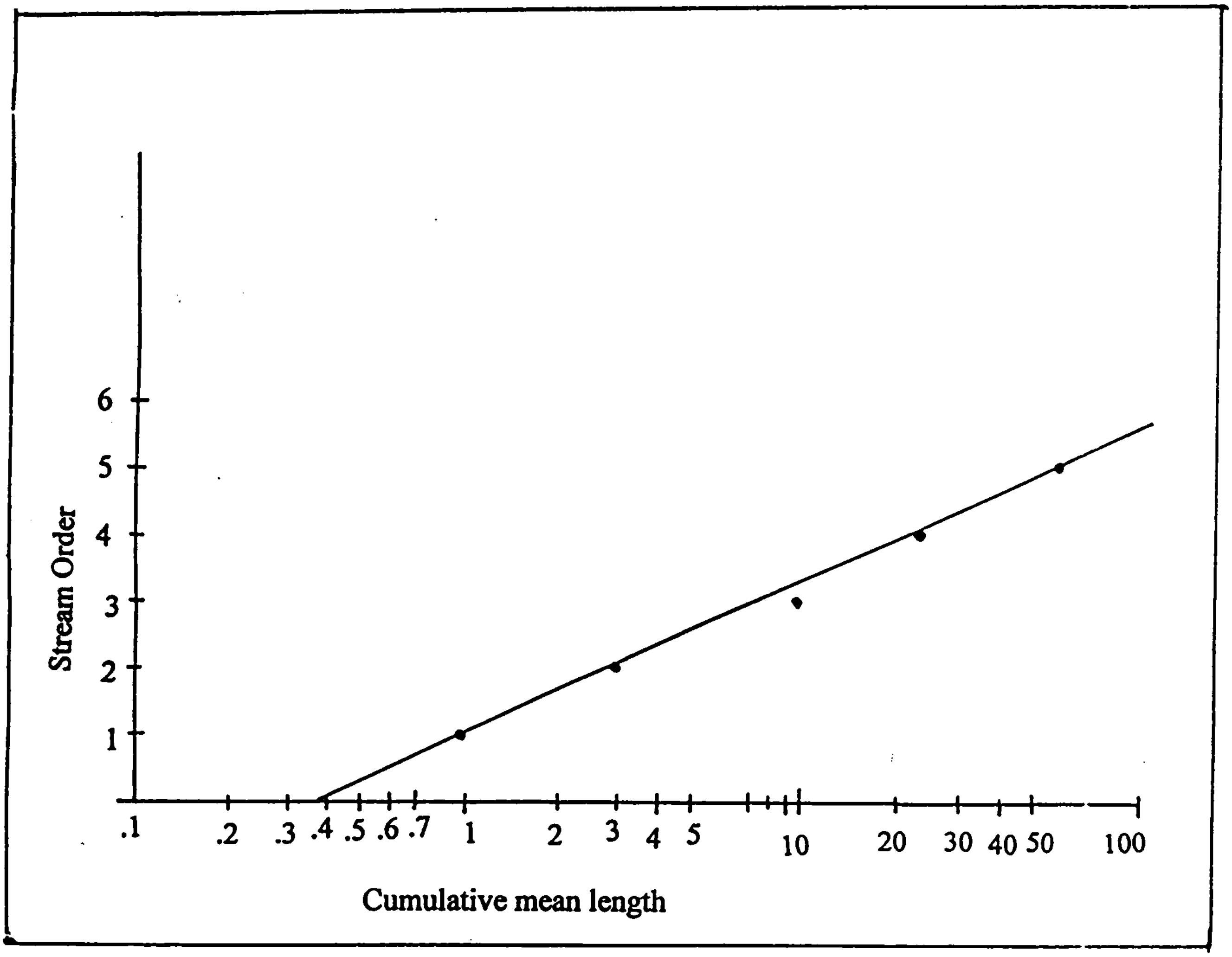
Cumulative mean length



Stream Order
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100
Cumulative mean length

Morphometric Analysis of the Nata Basin

Order of stream	Total no.of streams of individual order	Bifircation ratio
1st Order	337	3.96
2nd Order	85	4.47
3rd Order	19	6.33
4th Order	4	3.00
5th Order	1	-
	$\sum = 446$	

Order of stream	Total length of streams of individual order (cm)	Actual length (Km)
1st Order	330	165
2nd Order	170	85
3rd Order	125	62.5
4th Order	55	27.5
5th Order	35	17.5
		$\sum=357.5$

Order of stream	Length ratio	Actual mean length (Km)	Cumulative length
1st Order	0.51	0.98	0.98
2nd Order	1.36	2.0	2.98
3rd Order	2.27	6.57	9.55
4th Order	1.57	13.75	23.30
5th Order	-	35	58.30

Area of basin Cm2	km^2	Drainage density	Basin perimeter (Km)
734	183.5	1.94	64

Max.basin length (km)	Basin relief (m)	Relief ratio
20	511	0.590

Stream frequency	Form factor (Rf)	Elongation ratio
2.43	0.457	0.545 x 10-4

Circulatory ratio (Rc)	Infiltration no.	Length of overland flow
0.179	4.714	0.256

Max.basin relief	Relief ratio	Relative relief ratio
511 m	0.590	0.798

Ruggedness no. (HD)	Constant of channel maintenance (CM)
0.99	0.439

SUMMERY & CONCLUSION -

The morphological studies of various geomorphic units and land forms in the area have helped us in presenting a synaptic view of various Geomorphic and Morphometric study of the area.

The geomorphic evolution of the area has been polycyclic. The first geomorphic cycle was an erosional cycle, which leads to the development of a plain surface roughly corresponding to 300 m. elevation. The surface was covered from structurally and lithologically inhomogeneous envelope.

The second cycle of landscape evolution is characterized by valley deepening of the drainage channel of their aggradation surfaces, which was possibly triggered by lowering of base level of erosion.

The local relief characteristics of the basic geomorphic unit in the area appear to have been shaped by the second cycle, which still in its dynamic phase.

Lineament map shows that the NE-SW, NW-SE & NNE-SSW are the dominant lineament trends in Jamui area.

These have a strong control on the drainage system of the basin. A majority of the lineaments fall between $0^{\circ} - 40^{\circ}$ NE & $10^{\circ} - 40^{\circ}$ NW.

Areas with high lineament density are good for ground water development (Haridas et. al. 1994-98).

The study has been carried out by using remote sensing techniques, which revealed that the values of bifurcation ratio and drainage density indicate that the drainage might have been moderately affected by structural disturbance, has carried out the study and gently dipping beds developed over cuesta slopes.

Presence of dendratic drainage pattern with medium to coarse textured drainage with the area might be covered by Quaternary Sediments.

On the basis of the study of various parameters during Morphometric analysis, conducted in studied area, following conclusions could be drawn with reference to values of the parameters.

The values of these parameters are useful in determining the shape, nature, and structural disturbances of the area and the prevailing drainage network and its contributing basins surfaces. On the basis of the plots of the logarithm of the stream length versus stream order are generally in the linear pattern when basin evolution follows the erosion laws acting on the geologic material with homogenous weathering erosional characteristics.

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